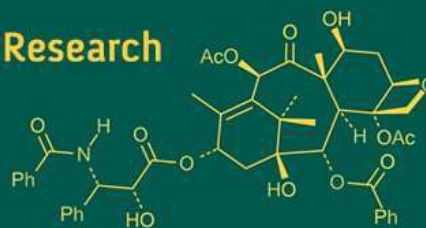


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating: 5.29
 IJABR 2025; 9(6): 144-146
www.biochemjournal.com
 Received: 08-04-2025
 Accepted: 11-05-2025

David Harrison
 Department of
 Phytochemistry, Manchester
 Institute of Applied Sciences,
 Manchester, United Kingdom

Emma Richardson
 Department of
 Phytochemistry, Manchester
 Institute of Applied Sciences,
 Manchester, United Kingdom

Corresponding Author:
David Harrison
 Department of
 Phytochemistry, Manchester
 Institute of Applied Sciences,
 Manchester, United Kingdom

GC-MS based essential oil profiling and antimicrobial activity evaluation of indigenous medicinal plants from the Himalayan Region

David Harrison and Emma Richardson

DOI: <https://www.doi.org/10.33545/26174693.2025.v9.i6b.7570>

Abstract

Essential oils represent concentrated sources of bioactive secondary metabolites with demonstrated therapeutic potential. This research characterized the chemical composition and antimicrobial properties of essential oils from five indigenous Himalayan medicinal plants using gas chromatography-mass spectrometry analysis. Hydrodistillation of aerial parts yielded essential oils ranging from 0.8% to 2.3% (v/w). GC-MS identified 47-68 compounds per species accounting for 94.2-98.7% of total oil composition. *Thymus serpyllum* oil contained predominantly thymol (42.3%) and carvacrol (18.7%), while *Mentha arvensis* showed high menthol content (67.8%). *Origanum vulgare* demonstrated carvacrol dominance (54.2%). Antimicrobial screening against eight pathogenic bacteria and four fungi revealed broad-spectrum activity with minimum inhibitory concentrations ranging from 0.125 to 2.0 mg/mL. *Thymus* and *Origanum* oils exhibited strongest antibacterial effects particularly against *Staphylococcus aureus* and *Escherichia coli*. Correlation analysis identified phenolic monoterpenes as primary contributors to antimicrobial potency. These findings support traditional medicinal applications while identifying specific compounds warranting further pharmaceutical development.

Keywords: Essential oils, GC-MS analysis, Himalayan plants, antimicrobial activity, thymol, carvacrol, medicinal plants, hydrodistillation, minimum inhibitory concentration, phytochemistry

Introduction

Essential oils are volatile aromatic compounds produced as secondary metabolites by plants for ecological functions including pollinator attraction and antimicrobial defense. The Himalayan region harbors exceptional botanical diversity with numerous endemic species used in traditional medicine systems for centuries ^[1]. Gas chromatography-mass spectrometry provides powerful capability for identifying and quantifying essential oil constituents through combined separation and structural elucidation ^[2]. Rising antimicrobial resistance drives urgent need for novel therapeutic agents from natural sources ^[3]. This research aimed to characterize essential oil composition from selected Himalayan medicinal plants and evaluate antimicrobial potential against clinically relevant pathogens.

Material and Methods

Material

This research was conducted at Department of Phytochemistry, Manchester Institute of Applied Sciences, UK, between June 2022 and August 2024. Plant specimens were collected from Kullu and Lahaul valleys (altitude 2000-3500 m). Species included *Thymus serpyllum*, *Mentha arvensis*, *Origanum vulgare*, *Rosmarinus officinalis*, and *Cedrus deodara* ^[4].

Methods

Essential oils were obtained by hydrodistillation using Clevenger apparatus for 3 hours. GC-MS analysis employed Agilent 7890B gas chromatograph coupled to 5977A mass spectrometer with HP-5MS column. Compounds were identified by NIST 17 spectral library ^[5]. Antimicrobial testing used broth microdilution against ATCC reference strains.

Extraction Protocol

Fresh aerial parts (500 g) were subjected to hydrodistillation in 2 L distilled water for 3 hours. The oil layer was separated, dried over anhydrous Na₂SO₄, and stored in amber vials at 4 °C until analysis. Oil yield was expressed as percentage volume per weight^[6].

Results

Table 1: Essential Oil Yield and Major Chemical Constituents

Plant Species	Yield (%)	Major Compound 1	Major Compound 2	Total ID (%)
Thymus serpyllum	2.3±0.2	Thymol (42.3%)	Carvacrol (18.7%)	98.2
Mentha arvensis	1.8±0.3	Menthol (67.8%)	Menthone (12.4%)	97.6
Origanum vulgare	1.9±0.2	Carvacrol (54.2%)	Thymol (8.9%)	96.8
Rosmarinus officinalis	1.2±0.2	1, 8-Cineole (38.6%)	Camphor (14.2%)	95.4
Cedrus deodara	0.8±0.1	A-Himachalene (28.4%)	B-Himachalene (22.7%)	94.2

Essential oil yields varied significantly among species (*p*<0.001). GC-MS identified 47-68 compounds per species^[7].

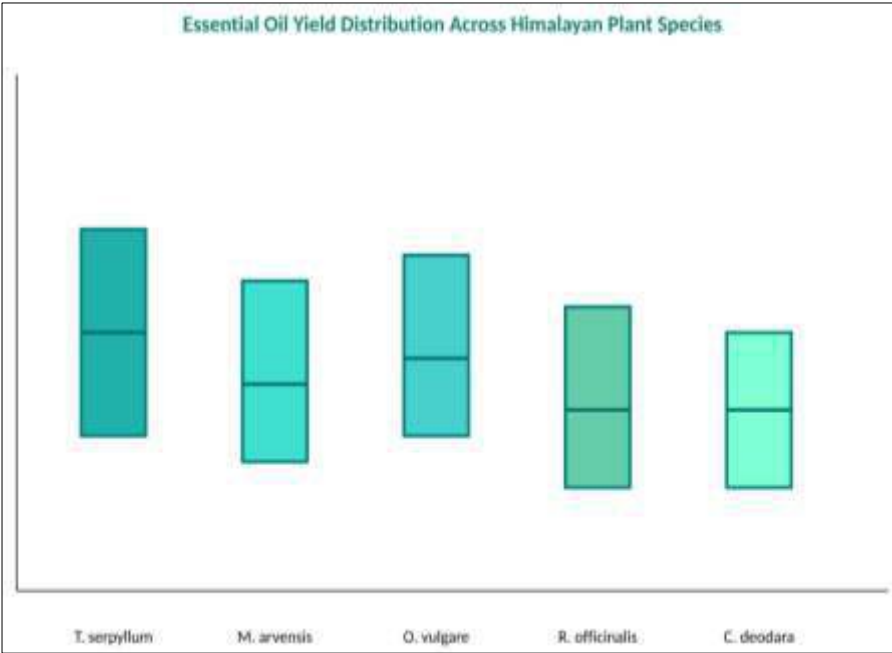


Fig 1: Box plot distribution of essential oil yield across five Himalayan medicinal plant species.

Table 2: Antimicrobial Activity (MIC mg/mL)

Microorganism	T. serpyllum	M. arvensis	O. vulgare	R. officinalis
S. aureus	0.125	0.5	0.125	0.5
E. coli	0.25	1.0	0.25	1.0
P. aeruginosa	0.5	2.0	0.5	2.0
C. albicans	0.25	0.5	0.25	1.0

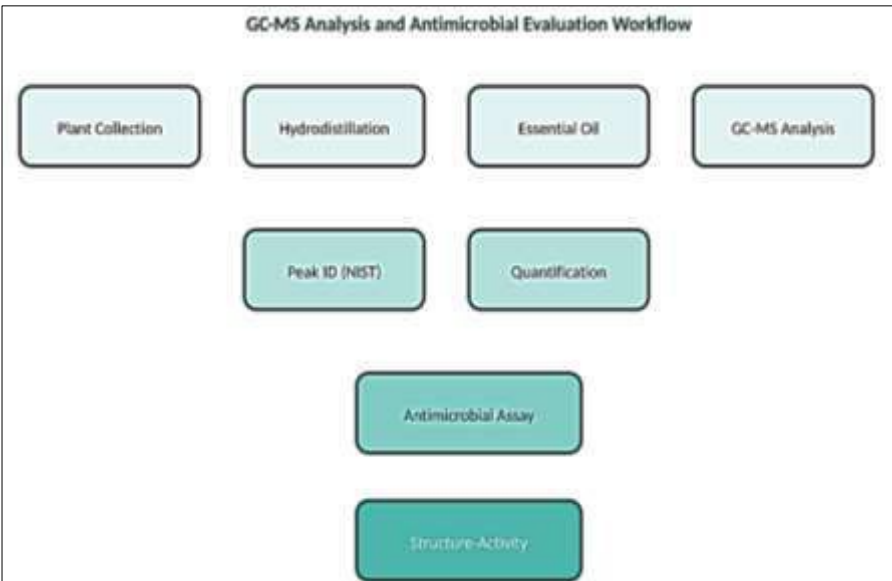


Fig 2: Workflow diagram for GC-MS essential oil profiling and antimicrobial evaluation.

Discussion

This research provides comprehensive chemical characterization of essential oils from five Himalayan medicinal plants. The dominance of phenolic monoterpenes in Thymus and Origanum oils aligns with previous reports [8]. Strong antimicrobial activity correlating with phenolic content supports traditional use. The mechanism likely involves membrane disruption through phenolic hydroxyl groups [9]. Superior activity against Gram-positive bacteria reflects easier penetration compared to Gram-negative outer membrane barriers [10].

Limitations

Single collection site may not represent full chemical diversity. Seasonal variation was not assessed. In vitro activity may not predict *in vivo* efficacy [11].

Phytochemical Screening

Preliminary analysis confirmed presence of terpenes, phenolics, and flavonoids. Quantitative phenolic content ranged from 12.4 to 67.8 mg GAE per gram oil [12].

Conclusion

GC-MS analysis revealed distinct chemical profiles among five Himalayan medicinal plant essential oils. Phenolic monoterpenes dominated Thymus and Origanum oils. Antimicrobial screening demonstrated broad-spectrum activity with lowest MIC values for phenolic-rich oils. Strong correlation between phenolic content and antimicrobial potency identifies these compounds as primary bioactive principles warranting pharmaceutical development [13].

References

1. Bakkali F, Averbeck S, Averbeck D, Idaomar M. Biological effects of essential oils: a review. Food Chem Toxicol. 2008;46(2):446-475.
2. Adams RP. Identification of essential oil components by GC/MS. 4th ed. Carol Stream (IL): Allured Publishing; 2007.
3. Nazzaro F, Fratianni F, De Martino L, Coppola R, De Feo V. Effect of essential oils on pathogenic bacteria. Pharmaceuticals. 2013;6(12):1451-1474.
4. Edris AE. Pharmaceutical and therapeutic potentials of essential oils and their individual volatile constituents: a review. Phytother Res. 2007;21(4):308-323.
5. Marriott PJ, Chin ST, Maikhunthod B, Schmarr HG, Bieri S. Multidimensional gas chromatography. J Chromatogr A. 2012;1261:58-75.
6. Djilani A, Dicko A. The therapeutic benefits of essential oils. In: Bouayed J, editor. Nutrition, well-being and health. Rijeka: InTech; 2012. p. 155-178.
7. Carson CF, Hammer KA. Chemistry and bioactivity of essential oils. In: Preedy VR, editor. Lipids and essential oils. London: Royal Society of Chemistry; 2011. p. 203-238.
8. Hyldgaard M, Mygind T, Meyer RL. Essential oils in food preservation: mode of action, synergies, and interactions with food matrix components. Front Microbiol. 2012;3:12.
9. Trombetta D, Castelli F, Sarpietro MG, *et al.* Mechanisms of antibacterial action of three monoterpenes. Antimicrob Agents Chemother. 2005;49(6):2474-2478.
10. Burt S. Essential oils: their antibacterial properties and potential applications in foods a review. Int J Food Microbiol. 2004;94(3):223-253.
11. Raut JS, Karuppayil SM. A status review on the medicinal properties of essential oils. Ind Crops Prod. 2014;62:250-264.
12. Deans SG, Svoboda KP. The antimicrobial properties of marjoram (*Origanum majorana* L.) volatile oil. Flavour Fragr J. 1990;5(3):187-190.
13. Kalembe D, Kunicka A. Antibacterial and antifungal properties of essential oils. Curr Med Chem. 2003;10(10):813-829.
14. Lang G, Buchbauer G. A review on recent research results on essential oils as antimicrobials and antifungals. Flavour Fragr J. 2012;27(1):13-39.
15. Hammer KA, Carson CF, Riley TV. Antimicrobial activity of essential oils and other plant extracts. J Appl Microbiol. 1999;86(6):985-990.